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Form Approved
OMB No. 0704-0188

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1. REPORT DATE **30 SEP 2013**	2. REPORT TYPE	3. DATES COVERED **00-00-2013 to 00-00-2013**

4. TITLE AND SUBTITLE **Multiscale Study of Currents Affected by Topography**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **University of California, San Diego,Scripps Institution of Oceanography,9500 Gilman Drive,San Diego,CA,92093**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR’S ACRONYM(S) 11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**2**	

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

Multiscale Study of Currents Affected by Topography

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Award Number: N00014-13-1-0479

LONG-TERM GOALS

This work seeks to understand the effects of topography on the ocean general circulation with a focus on the wide range of scales in the interactions. The small-scale details of the topography and the drag and turbulence generated at the boundary (at scales from meters to mesoscale) interact in the boundary layers to influence the larger-scale flow. We will study these issues through ocean model simulations, adjoint sensitivity experiments, and state estimation using measurements in the region surrounding an island in the westward-flowing limb of the subtropical gyre.

OBJECTIVES

The objectives of this program include addressing number of questions on ocean circulation that arise near islands and abrupt topography. Questions to study include:

- What is the steady-state flow around the feature, including isopycnal depths, currents, and water mass characteristics? How do these vary with changes in the surrounding large-scale flow?
- What is the response of the local flow to time-dependent large-scale flow? i.e., how does the feature scatter incoming Rossby waves (and near-inertial waves and tides) both barotropic and baroclinic, into outgoing waves, mean flows, and topographically-trapped waves?
- How much can be learned about the regional circulation or the larger scale currents from local observations? Can they be used for linear or nonlinear inverse estimates? i.e., can the regional or gyre circulation be monitored from tide gauges or other measurements near the feature?

The influence of the boundaries on the inner flow can also be turned around to study how the feature influences the larger-scale boundary flow. Example questions are: what form drag is exerted on the larger scale flow?. How turbulent are the wakes?. Are eddies shed?. If so, do shed eddies create counter-currents in the wake of the feature?

APPROACH

We will explore and answer these questions through numerical model-based data analysis, including state estimation in nested domains. We will use the MIT general circulation model (MITgcm) in an outer domain or nested domains up to basin scale, connected to a high-resolution (sub km) inner domain within about a degree of the island which will be configured and run by other investigators.

WORK COMPLETED

This work started four months ago, with a small amount of funding, but MITgcm forward and adjoint modeling studies of an idealized, flat-bottom, rectangular ocean basin containing an idealized island are in process to study the sensitivity of transport to wind stress in the vicinity of the island and through the section connecting the island to the boundary, generalizing the island rule.

RESULTS

The waveguides present in the basin (through beta and topography) determine the pathways of control of the transport, and are hypothesized to correspond to the integration contour for the island rule calculation, although sharp dependence on a single latitude is not observed.

IMPACT/APPLICATIONS

The boundary current transport sensitivity to local and basin-wide wind stress is quantified for time-dependent cases with arbitrary topography and existing background flows.

RELATED PROJECTS

REFERENCES

PUBLICATIONS